A Dissertation on

A COMPARISON OF THE TWO DIMENSIONAL ULTRASOUND GUIDED TECHNIQUE VERSUS THE TRADITIONAL BLIND ANATOMIC LANDMARK TECHNIQUE FOR THE PLACEMENT OF CENTRAL VENOUS CATHETER IN THE INTERNAL JUGULAR VEIN

Submitted in partial fulfillment of requirements

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CONTENTS

CERTIFICATE

This is to certify that the Dissertation "A COMPARISON OF THE TWO DIMENSIONAL ULTRASOUND GUIDED TECHNIQUE VERSUS THE TRADITIONAL BLIND ANATOMIC LANDMARK TECHNIQUE FOR THE PLACEMENT OF CENTRAL VENOUS CATHETER IN THE INTERNAL JUGULAR VEIN" presented herein by Dr.A.GANESH is an original work done in the Department of Anaesthesiology, Madras Medical College and Government General Hospital, Chennai for the award of Degree of M.D. (Branch X) Anesthesiology under my guidance and supervision during the academic period of 2003-2006.

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This is to certify that the Dissertation entitled "A COMPARISON OF THE TWO DIMENSIONAL ULTRASOUND GUIDED TECHNIQUE VERSUS THE TRADITIONAL BLIND ANATOMIC LANDMARK TECHNIQUE FOR THE PLACEMENT OF CENTRAL VENOUS CATHETER IN THE INTERNAL JUGULAR VEIN" presented herein by Dr.A.GANESH is an original work done in the Department of Anaesthesiology, Madras Medical College and Government General Hospital, Chennai for the award of Degree of M.D. (Branch X) Anesthesiology under the guidance and supervision of Dr.G.Sivarajan MD.,DA, Prof & HOD, Department of Anaesthesiology, Madras Medical College during the academic period of 2003-2006.

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DECLARATION

I, **Dr.A.GANESH**, solemnly declare that this dissertation entitled **"A COMPARISON OF THE TWO DIMENSIONAL ULTRASOUND GUIDED TECHNIQUE VERSUS THE TRADITIONAL BLIND ANATOMIC LANDMARK TECHNIQUE FOR THE PLACEMENT OF CENTRAL VENOUS CATHETER IN THE INTERNAL JUGULAR VEIN"** is a bonafide work done by me in the Department of Anesthesiology, Madras Medical College and Government General hospital, Chennai, during the period 2003-2006 under the able guidance of **Prof. G. Sivarajan, *MD., DA.*,** Professor and HOD, Department of Anesthesiology, Madras Medical College and Government General Hospital, Chennai – 3 and submitted to **The Tamilnadu Dr. MGR Medical University,** Guindy, Chennai – 32, in the partial fulfillment of the requirements for the award of the degree of MD Anaesthesiology (Branch X).

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INTRODUCTION

Central venous access is an essential part of patient management in many clinical settings. Central venous catheters are used for haemodynamic monitoring, giving vasopressors, cytotoxic drugs, blood sampling, transfusion of blood products, peri-operative intravenous fluid infusion, and parenteral nutrition [1].

Central venous cannulation is performed in a wide range of locations within the hospital as an elective or emergency procedure. Central venous access is commonly attempted at the internal jugular vein (IJV), subclavian vein (SCV), femoral vein, or arm veins using peripherally inserted central catheters. The actual site chosen in a particular patient should vary based on the indication, individual institutional and operator experiences. In most preoperative patients , IJV is the best route because of it's reliability and low rate of major complications with insertion. The right IJV has a direct path to the right ventricle and is associated with fewest catheter tip malpositions.

Placing central venous lines in the IJV entails risks. The standard conventional technique for placing central venous catheters in the IJV is by using anatomical landmarks [1]. Rates of major and minor complications can be as high as 10% [1]. The rates, risks and the consequences of complications vary according to patient groups (infants, obese patients), neck abnormalities, experience of the operator, the access site chosen, the condition of the patient, the presence of atypical vascular anatomy, the coagulation status of the patient, the history of previous catheterizations, awake or ventilated patients, elective or emergency cannulation. Each pass of a needle carries the risk of complications, so a successful first attempt is ideal. In heparinized patients undergoing cardio-pulmonary bypass , carotid artery punctures by a large bore needle may result in a large haematoma which may distort the anatomy, preventing further attempts at cannulation, postponement of surgery, haemorrhage requiring surgical intervention, or even death.

Ultrasound guided IJV cannulation is an emerging application of real-time two dimensional ultrasound technology. Since 1984 many authors have recommended ultrasound guidance to optimize the success rate of cannulations and minimize complications (14). Technical advances and a better understanding of anatomy have made insertion of central venous catheters easier and safer with ultrasound guidance, but there still is an underappreciation of the inherent risks. Conveniently, the internal jugular vein can be imaged with high frequency ultrasound probes. Familiarity with the equipment and cross-sectional anatomy are easy to gain safely by examining volunteers (66). Knowing that a vein is present, patent and not overlying an artery gives the operator more confidence while cannulating the internal jugular vein using ultrasond guidance (55).

AIM OF THE STUDY

1. The purpose of this study was to compare the two dimensional real-time ultrasound guided technique with the traditional blind anatomic landmark technique for the placement of central venous catheter in the internal jugular vein of patients posted for major elective cardiac surgeries.

2. To compare the outcome between the ultrasound guided technique versus the landmark technique in terms of the following parameters : the time taken to locate the IJV with the probe / pilot needle, time taken to locate the IJV with the 18 G needle, the number of venipunctures, the number of attempts required to successfully cannulate the IJV, the total access time, the success rate, the failure rate, the complication rate .

HISTORICAL PERSPECTIVES

1952 – Aubaniac[1] gave the first description of infraclavicular subclavian venipuncture in humans.

1953 – Seldinger[2] described the replacement of a catheter needle using a guidewire during central venous cannulation.

1955 – Percutaneous catheterization of the inferior vena cava via a femoral vein approach became popular until reports of a high incidence of complications were published[3,4].

1959 – Hughes and Magovern[5] described the clinical use of central venous pressure measurements in humans undergoing thoracotomy.

1962 – Wilson and associates[6] extended the practicality of central venous pressure monitoring by using percutaneous infraclavicular subclavian vein catheterization.

1962 - Yoffa[7] reported his experience with supraclavicular subclavian venipuncture, claiming a lower incidence of complications, but his results were not uniformly reproduced.

1962 - Nordlund and Thoren[8] and then Rams and associates[9] performed external jugular vein catheterization with fewer complications but positioning of the catheter tip in a central venous location was sometimes impossible.

1966 – Hermosura and colleagues[10] described the technique IJV cannulation and advocated it's use in adults.

1969 – English et al,[11,12] reported the first large series (500 cases) of IJV cannulations. Subsequently the procedure became more common, and in many centers the preferred method of central venous access.

1974 – Blitt et al,[13] described a technique of central venous cannulation via the EJV employing a J wire . Although the success rate of this route is lower than with the IJV, a central venipuncture is avoided, and in selected cases catheterization via the EJV is an excellent alternative.

1984 – Legler and Nugent[14] first reported the use of ultrasound to assisst IJV cannulation in the anaesthesiology literature.

ANATOMY OF THE INTERNAL JUGULAR VEIN

The internal jugular vein collects blood from the skull, brain, superficial parts of face, and much of the neck. It begins at the cranial base in the posterior compartment of the jugular foramen, continuous with the sigmoid sinus. At it's origin is it's superior bulb, which is below the posterior part of the tympanic floor. The vein descends in the carotid sheath, uniting with the subclavian, posterior to the sternal end of the clavicle, to form the brachiocephalic vein. It is also dilated near it's end as its inferior bulb, above which it contains a pair of valves. Posterior to the vein from above are : the rectus capitis lateralis, transverse process of atlas, levator scapulae, scalenus medius, and the cervical plexus, scalenus anterior, phrenic nerve, thyrocervical trunk, vertebral vein and first part of subclavian artery; on the left it also crosses anterior to the thoracic duct. Medial to the vein are the internal and common carotid arteries and the vagus nerve between vein and arteries but posterior to them. Superficially the vein is overlapped above, then covered below by sternocleidomastoid and crossed by the posterior belly of the digastric, and the superior belly of omohyoid. Superior to the digastric, the parotid gland and the styloid process are superficial, the accessory nerve, posterior auricular and occipital arteries crossing the vein. Between the digastric and the omohyoid, sternocleidomastoid arteries and the inferior root of the ansa cervicalis cross it, but the nerve often passes between the vein and the common carotid. Below the omohyoid it is covered by the infrahyoid muscles and the sternocleidomastoid and it is crossed by the anterior jugular vein. Deep cervical lymphnodes lie among the vein, mainly on it's superficial aspect. At the root of the neck the right IJV is separated from the common carotid, but the left IJV usually overlaps its artery. At the base of the skull the internal carotid artery is anterior, separated from the vein by the ninth to twelfth cranial nerves.The junction of the right IJV (which averages 2-3cm in diameter) with the right subclavian vein and then the innominate vein forms a straight path to the SVC. As a result, malpositions and looping of a catheter inserted through the right IJV are unusual. In contrast, a catheter passed through the left IJV must negotiate a sharp turn at the left jugulo-subclavian junction, which results in a greater percentage of catheter malpositions [15] . This sharp turn may also produce tension and torque at the catheter tip, resulting in a higher incidence of vessel erosion [16,17] . Knowledge of the structures neighbouring the IJV is essential, because they may be invaded by a misdirected needle.

SURFACE ANATOMY

The vein is represented in surface projection by a broad band from the ear's lobule to the medial end of the clavicle; it's inferior bulb is in the interval (depression) between the sternal and clavicular heads of the sternocleidomastoid (i.e., the bulb bulges into the lesser supraclavicular fossa; a needle may be inserted here with precision).

TRIBUTARIES

The inferior petrosal sinus, facial, lingual, pharyngeal, superior and middle thyroid veins, sometimes the occipital. It may communicate with the external jugular vein. The thoracic duct opens near the union of the left subclavian and internal jugular veins; the right lymphatic duct is at the same site on the right.

LANDMARK TECHNIQUES OF IJV CANNULATION

Internal jugular venipuncture may be accomplished by a variety of methods .All methods use the same landmarks but differ in the site of venipuncture or orientation of the needle. There are three general approaches[18]:

1. Central approach,
2. Anterior approach,
3. Posterior approach.

The method chosen varies with the institution and the operator's experience. All approaches require identical equipment, and the operator may choose from many different catheters and prepackaged kits.

1. **Central approach** [12, 18-22]

This approach described by Daily and colleagues [20] is the most popular technique. Skin puncture is at the apex of the triangle formed by the two muscle bellies of the sternocleidomastoid muscle and the clavicle. The ICA pulsation is usually felt 1 to 2cm medial to this point, beneath or just medial to the sternal head of the muscle. The skin at the apex of the triangle is infiltrated with 1% lidocaine using the 22-gauge needle, which is then used to locate the IJV. Use of a small-bore finder needle to locate the IJV should prevent inadvertent ICA puncture and unnecessary probing with a larger-bore needle. The operator should maintain slight or no pressure on the ICA with the left hand and insert the finder needle with the right hand at the apex of the triangle (or slightly caudal) at a 30- to 45-degree angle with the frontal plane , directed at the ipsilateral nipple. After expulsion of any skin plug, the needle is advanced steadily with constant back pressure and venipuncture occurs within 3 to5 cm. Deeper penetration is not recommended. If venipuncture does not occur on the initial thrust, back pressure should be maintained and the needle slowly withdrawn, as venipuncture frequently occurs on withdrawal. If the first attempt is unsuccessful, the operator should reassess the patient position, landmarks and techniques to ensure that he or she is not doing anything to decrease IJV lumen size. Subsequent attempts may be directed slightly laterally or medially to the initial thrust, as long as the plane of the ICA is not violated. If venipuncture does not occur after three to five attempts, further attempts are unlikely to be successful and only increase complications[22,23,24] .

When venipuncture has occurred with the finder needle, the operator can either withdraw the finder needle and introduce the large bore needle in the identical plane or leave the finder needle in place and introduce the larger needle directly above it. If using the latter technique, the operator or assistant must be careful not to exert tension on the finder needle, as this may decrease the lumen size of the IJV and make catheterization more difficult. With the 18G thin-wall needle, the operator must be sure to secure the needle in place with one hand while removing the syringe with the other, so that the needle does not migrate out of the vein prior to guide wire insertion. Once venipuncture has occurred the syringe is removed during expiration or valsalva maneuver and the hub occluded with a finger after ensuring that the backflow of blood is not pulsatile. The j-tip of the guide wire is then inserted and should pass freely up to 20cm, at which point the thin-wall needle is withdrawn. The tendency to insert the guide wire deeper than 15 to 20 cm should be avoided, as it is the most common cause of ventricular arrhythmias during insertion and also poses a risk for cardiac perforation. Occasionally the guide wire does not pass easily beyond the tip of the thin-wall needle. The guide wire should then be withdrawn, the syringe attached, and free backflow of blood reestablished and maintained while the syringe and the needle are brought to a more parallel plane with the vein. The guide wire should then pass easily. If resistance is still encountered, rotation of the guide wire during insertion often allows passage, but extensive manipulation and force only leads to complications. With the guide wire in place, a scalpel is used to make two generous 90-degree stab incisions at the skin entry site to facilitate passage of the 7-Fr vessel dilator. The dilator is inserted down the wire to the hub, ensuring that control and sterility of the guide wire is not compromised. The dilator is then withdrawn and gauze used at the puncture site to control oozing and prevent air embolism down the needle tract. The triple-lumen catheter is then inserted over the guide wire, ensuring that the guide wire protrudes from the distal lumen hub before the catheter tip penetrates the skin. The catheter is then advanced 15 to 17cm into the vein, the guide wire withdrawn, and the distal lumen capped. The catheter is sutured securely to limit tip migration and bandaged in a standard manner.

A chest radiograph should be obtained to detect complications and tip location. Central venous catheters placed in the operating room are generally used for the duration of the surgical procedure without first confirming the location of the catheter tip radiographically. After surgery, however, the position of the catheter tip must always be confirmed radiographically.

2.**Anterior approach** [18,25,26,27]

This approach differs in the venipuncture site and the plane of insertion. The important landmark is the midpoint of the sternal head of the sternocleidomastoid muscle, approximately 5cm from both the angle of the mandible and the sternum. At this point, the carotid artery can be palpated 1cm inside the lateral border of the sternal head. The index and middle fingers of the left hand gently palpate the artery, and the needle is introduced 0.5 to 1cm lateral to the pulsation. The needle should form a 30 to 45-degree angle with the frontal plane and be directed caudally parallel to the carotid artery towards the ipsilateral nipple. Venipuncture occurs within 2 to 4cms , sometimes only while the needle is slowly withdrawn. If the initial thrust is unsuccessful, the next attempt should be at a 5-degree lateral angle, followed by a cautious attempt more medially, never crossing the plane of the carotid artery.

3. **Posterior approach** [18,28,29,30]

This approach uses the EJV as a surface landmark. The needle is introduced 1cm dorsally to the point where the EJV crosses the posterior border of the sternocleidomastoid muscle or 5cm cephalad from the clavicle along the clavicular head of the sternocleidomastoid muscle . The needle is directed caudally and ventrally towards the suprasternal notch at an angle 45 degrees to the sagittal plane, with a 15-degree upward angulation. Venipuncture occurs within 5 to 7 cm. If this attempt is unsuccessful, the needle should be aimed slightly more cephalad on the next attempt.

SUCCESS RATES

IJV catheterization is associated with a high rate of successful catheter placement regardless of the approach used. Elective procedures are successful more than 90 % of the time, generally within the first three attempts, and catheter malposition is rare [15,18,19,20,22,25,26,31]. Operator experience does not appear to be as important a factor in altering the success rate of venipuncture as it is in altering the success rate of venipuncture as it is in increasing the number of complications[22,32]. Emergency IJV cannulation is less successful than elective procedure.

COMPLICATIONS

The incidence and types of complications are similar regardless of the approach. Operator's inexperience appears to increase the number of complications, but to an undefined extent, and probably does not have as great an impact as it does on the incidence of pneumothorax in subclavian venipuncture [18,33,34]. The overall incidence of complications in IJV catheterization is 0.1% to 4.2% [18,28,33,35]. Important complications include ICA puncture, pneumothorax, vessel erosion, thrombosis, and infection. By far the most common complication is ICA puncture, which constitutes 80% to 90% of all complications. In the absence of a bleeding diathesis, arterial punctures are benign and are managed conservatively without sequelae by applying local pressure for 10 minutes. Even in the absence of clotting abnormalities, a sizable haematoma may form, frequently preventing further catheterization attempts or, rarely exerting pressure on vital structures[36,37]. Unrecognized arterial puncture can lead to catheterization of the ICA with a large-bore catheter or introducer and can have disastrous consequences, especially when heparin is administered[38] . Chronic complications, which results from ICA puncture, include haematomas requiring surgical excision, arterio-venous fistula, and pseudoaneurysm. Pneumothorax has an average incidence of 0% to 0.2% [22,29,33,35] . It usually results from a skin puncture too close to the clavicle. Pneumothorax can be complicated by heme infusion, or tension [17] .

Other complications include haemothorax, haemomediastinum, arterial thromboembolism, subcutaneous/mediastinal emphysema, chylothorax, endotracheal tube cuff puncture, catheter tip malposition, and catheter related sepsis.

BASIC PRINCIPLES OF ULTRASOUND

Ultrasound is sound with a frequency greater than 20,000Hz.Medical sonography employs frequencies between 1MHz and 20 MHz. These high frequencies are produced by subjecting a special ceramic material, a piezoelectric crystal, to a short voltage spike .The electric field created by the voltage spike realigns crystalline elements (dipoles) in the ceramic, thereby suddenly changing the crystal's thickness. This sudden change in thickness starts a series of vibrations that produces sound waves. A longitudinal wave is propagated by multiple particles oscillating in the direction of propagation to produce bands of compression and rarefaction in the conducting medium. When these bands are back scattered to the piezoelectric crystal as echoes they change the crystals thickness, which produces an electrical signal. This signal forms the basis of the ultrasonic image. The sound is transmitted in short bursts or pulses, usually 1000/sec. The pulses are short about 0.000001 sec in duration. Between the pulses the transducer acts as a receiver, recording returning echoes. The time delay between the initiation of a pulse and the return of an echo is converted into depth in all imaging modes. The images can be displayed in several modes. Multiple controls are provided to augment weaker echoes(67) .

Ultrasonic image[68] :

The ultrasonic image is an electronic representation of data generated from returning echoes and displayed on a TV monitor. The image is assembled , one bit at a time, much like a television image. Each returning echo generates one bit of data, and many bits together form the electronic image. The evolution of sonic imaging began slowly from a static one-dimensional base (A mode) , improved somewhat when a component of motion was added (TM mode), and made giant leaps forward with two-dimensional imaging (B Mode) , grey-scale imaging and real-time imaging.

Real-time ultrasound[68] :

Real-time imaging systems are those that have frame rates fast enough to allow movement to be followed. With the conventional B mode system the operator produces a single image frame with the transducer. This single frame is viewed until it is erased and a new image is generated. A real-time transducer can produce multiple frames in a very short time , typically at least 10 frames per second. This fast frame rate allows movement to be viewed in real-time as the images are generated. Because of the short persistence of vision, a flicker free display requires at least 16 frames per second.

Choice of operating frequency[68] :

Absorption in tissue is proportional to frequency ; that is , increasing from 1 to 2 MHz doubles absorption and halves the penetrating power of the beam. Therefore, high frequency probes (7.5 to 10 MHz) are used to visualize superficial structures like IJV, carotid artery and vessels in the limbs.

ULTRASOUND GUIDED IJV CANNULATION

The use of ultrasound localization to aid in IJV catheterization improves success rate and decreases the need for multiple attempts [39,40,46,47,48] but it has not been widely adapted, probably because of cost and training issues.

Medical ultrasound devices may be used to locate the IJV in the following ways

1. Real-time ultrasonography generates two-dimensional grey scale image of the vein and the surrounding structures.

2. Continuous wave Doppler ultrasonography generates an audible sound from flowing venous blood (based on distinguishing the continuous audible hum of the vein from the pulsatile signal of the artery), with no information on the depth of the vessel.

3. A diagnostic echocardiograph machine can be used to image the vascular anatomy.

4. Transesophageal echocardiography has been used to guide central venous catheterization [49]

Most investigators have shown that ultrasound guidance reduces the time required, increases the overall success rates, and results in fewer complications [39,50] . In special circumstances, ultrasound or Doppler localization is helpful in performing difficult or previously unsuccessful IJV catheterization [40,41,42] .

Two dimensional USG guided technique :

The ultrasound probe is covered with a elongated sterile sheath containing ultrasound transmission gel. The probe is placed on the right side of the neck, perpendicular to the vessels just lateral to the trachea and superior to the clavicle by the operator's left hand. After identifying the pulsating vessels, the central mark of the probe is placed over the center of the internal jugular vein. The needle is seen to indent the overlying skin and dimple the vein, when the needle point is positioned correctly. Excessive pressure on the skin by the transducer can compress the vein but not the artery. The needle is advanced into the vein as directed by the ultrasound image. As soon as the needle is seen entering the vein, dark venous blood can be aspirated freely and the needle is stabilized such that the tip is in the center of the vessel lumen. Then the probe is held by the observer, while the operator follows the regular steps of Seldinger technique to thread the triple lumen central venous catheter over the guide wire . The position of the guide wire and subsequently the catheter can be confirmed with the ultrasound probe adjustments in the longitudinal axis.

Ultrasound studies have been useful in delineating factors that improve the efficiency of IJV cannulation. The ability to perform IJV puncture is directly proportional to it's cross-sectional lumen area (CSLA); thus, maneuvers that increase or decrease the vein's caliber impact on the success rate [43,44] . Maneuvers that decrease the CSLA include hypovolemia, carotid artery palpation, and excessive tension on a finder needle. Predictably, Valsalva maneuver, and Trendelenburg position increase CSLA, as does PEEP. There is also a progressive increase in CSLA as the IJV nears the Subclavian vein. Over rotation of the neck may place the vein beneath the sternocleidomastoid muscle belly (43) .Ultrasound has been used to study anatomical variations (44,45) . Use of Doppler device (Smart-Needle) or an ultrasound has improved success rate in difficult cases with anatomical variation (41,42) .

However, the landmark based techniques are still performed because of the relatively high success rate and low morbidity of this procedure when performed by experienced individuals, the additional cost and the perceived inconvenience of acquiring and using an ultrasound device, and concern that reliance on ultrasound guided catheterization will prevent trainees from acquiring adequate skills for landmark based central venous cannulation.

REVIEW OF LITERATURE

The use of ultrasound to guide central venous access has been previously reported(14,59,60,61) . Ultrasound has been applied to describe the anatomy of the IJV and to evaluate various techniques for percutaneous cannulation (62, 63) . Denys and Uretsky (45) studied the normal anatomy of the IJV in 1993. The anatomy of the IJV was sufficiently aberrant in 8.5% of cases to complicate access by a landmark method, and five patients (2.5%) had thrombosed IJV.

Yonei and Sari et al. 1986 [(59)]

The first report of combined real-time ultrasonographic imaging and internal jugular catheter placement was by Yonei and Sari. They used a sterile 5 MHz probe to identify the IJV and carotid artery during placement of internal jugular catheters in the intensive care unit, and successfully catheterized 160 patients without complication or failure.

Mallory and Shawker et al, 1990 [(64)]

They compared ultrasound guidance and external landmark technique in 27 critically ill patients. Despite the small number of patients, an improvement in success rate and a reduction in the number of attempts were reported compared with the traditional approach. Using the Landmark technique, 24.8% of the patients required more than two attempts for successful cannulation versus only 7.3% in the Ultrasound group. Also noted, the complication rate was low and patient discomfort resulted from multiple attempts and switching sites because of unsuccessful cannulation.

Troianos et al, 1991 [(48)]

They conducted a prospective randomized control trial (level 2b) in 160 cardiothoracic surgical patients needing right IJV cannulation , comparing 2 D ultrasound (Site rite) versus Landmark technique. The patients were randomized into two groups : Group Usg (n=77), Group Control (n=83). The Usg group required less time for cannulation (61+/- 46 sec) when compared to the Control group (117+/- 13 sec). The mean number of attempts were less in the Usg group (1.4 +/- 0.7) when compared to that of Control group (2.8 +/- 3.0). The Usg group had 100% success rate when compared to the Control group (96.4%). The Usg group had higher success rate at the first attempt (73%) than the Control group (54%). The major complication they came across was carotid artery puncture. The Usg group had less complication rate (1 out of 77, 1.4%) when compared to the Control group (7 out of 83, 8.43%). Of the 3 patients who could not be cannulated using the external landmarks, 2 patients were cannulated at the first attempt with ultrasound and the third patient was cannulated via the EJV. These data revealed significant reduction in the time taken for cannulation, in the incidence of complications, in the number of attempts required, and higher success rate at first attempt in the Ultrasound guided technique.

Armstrong et al, 1992 [51]

They compared the use of real-time ultrasound to delineate vessel anatomy with the technique using only anatomic landmarks. The study included 115 patients undergoing coronary artery bypass surgery. In the Ultrasound group (n=58) the Site-rite was used to explore the vascular anatomy and in the Landmark group (n=57), the normal anatomical landmarks were used. After induction of anaesthesia, a Right IJV was cannulated by a standard high approach. Anticipated ease of insertion (using a Four-point scale)was predicted in all patients using anatomical landmarks alone. They concluded that use of the Site-rite was found to be easy in all cases with visualization of the neck anatomy simple to obtain and interpret. After using the Site-rite, the anticipated ease of cannulation was found to be improved in comparison to that anticipated (F=0.04) in the same subjects and also compared with the control group (F=0.01; Mann-Whitney). They found an increase in the speed of cannulation, a decrease in the number of attempts, and a reduced failure rate after defining the vessel anatomy with ultrasound, but found no difference in the carotid artery puncture rate. Inability to visualize the catheter entering the vein and going through the vein into the underlying artery may explain the reason for arterial puncture using this variation of the Ultrasound technique.

Alderson et al, 1993 [52]

They investigated the possibility that anatomical factors contribute to the difficulties in IJV cannulation by using a 2-D ultrasound scanner to examine venous anatomy in children aged up to 6 years. They found that 18 % of the children had anomalous venous anatomy that may account for some of the difficulties reported previously. The diameter of the IJV was predicted poorly by the patient's age or weight. They also evaluated the use of the ultrasound scanner during percutaneous cannulation in neonates and infants. They concluded that determining the course of the IJV with the scanner and then marking it on the overlying skin reduced both the time and number of needle insertions required for successful cannulation and increased the chance of a complication free cannulation.

Dennys and Reddy et al, 1993 [40]

They studied the use of ultrasound guidance in the IJV catheterization in a larger controlled comparison study. They compared 302 patients undergoing jugular vein puncture for placement of a central venous catheter in the cardiac catheterization laboratory. Results included significantly higher success rates, a lower number of attempts., and a lower complication rate with ultrasound guidance. Ultrasound guided technique allowed a marked reduction in the access time.

Vucevic et al, 1994 [53]

They conducted a prospective randomized controlled trial (level 3b) which included 40 patients requiring central venous cannulation for cardiac surgery or Intensive care. Patients were grouped into perceived easy and difficult cannulation and then randomized to SMART needle or Landmark technique.The 4 groups were Easy Control (n=10), Easy SMART (n=10), Difficult Control (n=10), Difficult SMART (n=10). The procedure was performed by two senior anaesthetists.In the Ultrasound group, SMART needle Doppler ultrasound probe (probe within needle) was used. The mean time taken for cannulation in the SMART group (Easy-91.8 sec, Difficult-167.6 sec), in the Control group (Easy-59.2sec, Difficult-322.6 sec). The incidence of complications in the SMART group was 5% (1/20) and in the Control group was 5% (1/20). The data revealed significant reduction in the time taken for cannulation and in the number of attempts with similar complication rate in the Ultrasound group.

Gratz et al, 1994 (47)

They conducted a prospective randomized controlled trial (level 3b) in 41 patients posted for Cardiothoracic or major vascular surgery needing IJV cannulation. The Ultrasound guided group underwent central line placement with SMART needle. The mean time taken for cannulation in the Ultrasound group was 109 sec (6-470 sec) and in the Control group was 226 sec (5-1200 sec). The mean number of attempts was 1.35 (1-4) in the Ultrasound group and 2.8 (1-10) in the Control group. The success rate at first attempt was 85% (17/20) in the Ultrasound group and 55% (11/20) in the Control group. The incidence of complications was 0 in both the groups. The study concluded that there was significant reduction in the time taken for cannulation and in the number of attempts along with better success rate at the first attempt in the Ultrasound group.

Slama M, et al, 1997(70)

They conducted a prospective randomized study in 79 ICUpatients Who were assigned to internal jugular vein cannulation using anatomical landmarks alone (n=42) or with ultrasound guidance (n=37). They concluded that Ultrasound guidance improved the success rate of jugular vein cannulation in ICU patients. They also suggested that Ultrasound guidance should be used when the internal jugular vein has not been successfully cannulated within 3 min by the external landmark-guided technique.

Verghese et al, 1999 [54]

They conducted a prospective randomized study in 95 infants scheduled for cardiac surgery. The patients were randomly allocated into two groups (Ultrasound group, Landmark group). The time taken for cannulation was 4.2 +/- 2.8 (3.3) min in the Ultrasound group and 14 +/- 15.1 (10) min in the Landmark group. The number of attempts was 1.3 +/-0.6 (1) in the Ultrasound group and 3.3 +/- 2.8 (2) in the Landmark group. The success rate was 100% in the Ultrasound group when compared to 76.9% in the Landmark group. The carotid artery puncture rate was 0 in the Ultrasound group while 25 % in the Landmark group. They concluded that Ultrasound guidance significantly reduces the time taken , the number of attempts ,the complications along with 100% success rate.

Hatfield and Bodenham et al , 1999 [69]

They studied the use of ultrasound in patients who were predicted to be difficult to cannulate. They chose 33 patients , out of which 23 had previous cannulation failure or complications from previous cannulation attempts and the others were simply predicted to be difficult to cannulate. In 16 of these 23 difficult patients, Ultrasound imaging demonstrated an anatomical reason for the difficulty , including the presence of a small vein or venous thrombosis. Using real-time ultrasound guidance, cannulation was successful in 22 of 22

(100%) attempted ,with 20 of 22 (90.9%) being successful on the first attempt and the remaining two successful on the second pass. They concluded that Ultrasound guidance improves the success rate in difficult cases when compared to the Landmark technique.

Sulek et al, 2000 [55]

They conducted a prospective randomized controlled trial (level 3b) in 120 patients posted for elective abdominal, vascular or cardiothoracic surgery. The patients were randomized into 4 groups (30 patients each) : Group1- Right IJV Landmark technique, Group2- Right IJV 2- D Ultrasound technique, Group3- Left IJV Landmark technique, Group4- Left IJV 2- D Ultrasound technique. The results expressed as Groups 1 vs 2 vs 3 vs 4 . The time taken for guidewire insertion was 137+/- 139 vs 58+/-71 vs 247+/- 176 vs 138 +/- 142 sec (Left IJV > Right IJV, Landmark > Ultrasound). The number of attempts for guidewire insertion was 2.1 +/-0.9 vs 1.5 +/-2 vs 3.5 +/-1.3 vs 2.3 +/-0.7 (Left IJV > Right IJV, Landmark > Ultrasound). The incidence of failed guidewire placement 3.3% vs 3.3% vs 13.3% vs 6.7% (Left IJV > Right IJV, Landmark > Ultrasound). The incidence of complications (combined artery puncture and haematoma) was 18/20 (15% overall complication rate) , 13.3% vs 6.7% vs 26.7% vs 13.3% (Left IJV> Right IJV, Landmark > Ultrasound). They concluded that Ultrasound significantly reduces the time taken, the number of attempts required and the complications while improving the success rate of IJV cannulation.

NICE guidelines, 2002, UK [56]

A systematic review and meta-analysis (level 1a) was done including 20 Randomized controlled trials evaluating ultrasound guidance for central line placement.20 RCTs were identified. Of these 6 evaluated audio-guided Doppler ultrasound against the Landmark method, 13 evaluated 2- D Ultrasound guidance against the Landmark method and 1 trial evaluated both audio-guided Doppler Ultrasound and 2-D Ultrasound guidance against a control as well as each other. Only 4 trials were in the adult cardiac setting. Insertion sites were the IJV (15 trials), SV (4 trials), FV (1 trial).Pooled results from 7 RCTs suggested that real-time 2-D Ultrasound guidance was significantly better than the Landmark method for all 5 outcome variables measured. Compared with the Landmark method, 2-D Ultrasound guidance was associated with reduced risks of failed catheter placements (86% reduction in the risk, 95% CI 67% to 94%, p <0.001), catheter placement complications (57% reduction in risk, 95% CI 13% to 78%, p =0.02), and failure on the first catheter placement attempt (41% reduction in risk, 95% CI 12% to 61%, p= 0.009), and fewer attempts to achieve successful catheterization (on average, 1.5 fewer attempts, 95% CI 0.47 to 2.53, p=0.004). The difference in the time taken to successful catheterization was small and not statistically significant (the 2-D Ultrasound guided catheterization was 20 sec faster, 95%CI 83 to124 sec, p=0.7). However there was significant heterogeneity for this end point (p<0.01), which indicated that it might not be appropriate to pool these results. Based on these conclusions they recommended that use of 2-D Ultrasound should be considered in most clinical situations where a central line is necessary electively or in an emergency.

Adam H. Miller, et al[71]

They conducted a prospective study of consecutive patients enrolled at a University teaching hospital. They compared the Ultrasound-guided technique(n=51) versus the landmark-guided technique(n=71) for emergency central venous access with 17 variables. They found that Ultrasound guidance was better than Landmark technique and recommended it's use in difficult patients and during unsuccessful cannulation by Landmark technique.

Hind et al, 2003 UK [57]

They conducted a systematic review and meta-analysis (level 1a) which included 18 trials (1646 patients) either Doppler or 2-D Ultrasound guided central line placement compared to landmark method in a range of clinical settings. They searched 15 bibliographic databases until October 2001, as part of the NICE guideline development process. In adults for Right IJV cannulation the time taken for catheter placement was on an average 69 sec quicker with 2-D Ultrasound (CI 46-92 sec), average 34 sec slower with Doppler probe (CI 54-124 sec). The incidence of failed catheter placement was 5/266 (1.7%) in the Ultrasound group, 68/312 (22%) in the Landmark group (Odd's ratio 0.14, CI0.06-0.33). The incidence of complications was calculated and the relative risk of complication while using the Ultrasound was 43% less than the risk using Landmark method (CI 22% to 87 %).

Tosuimi Arai et al, 2004 [58]

They conducted a prospective randomized study comparing two different techniques of Ultrasound guided internal jugular access in infants and children . The patients were randomized into two groups : Ultrasound scanner group (29 patients), Audio-Doppler group (33 patients). The percentage of patients cannulated within 5 min was 75.9% in the Ultrasound group when compared to 60.6% in the Audio-Doppler group (not statistically significant). But the higher success rate on first attempt in the Ultrasound group (65.5% vs 39.4%) was statistically significant. The Ultrasound group had a higher ultimate success rate (89.7% vs 78.8%) but it was not statistically significant. The incidence of complications , namely, haematoma (3/33 vs 1/29) and artery puncture (2/33 vs 0/29) was less in the Ultrasound group.

MATERIALS AND METHODS

Study Design :

This study was conducted in the Cardio-thoracic operation theatre at the Government General Hospital ,Chennai between May 2005 and August 2005 on forty patients posted for elective major cardiac surgery. The study was done after institutional approval and written informed consent was obtained from all the patients included in the study.

This study was done in a prospective randomized manner. Forty patients of either sex posted for major elective cardiac surgeries satisfying the selection criteria were randomly allocated into the two groups (Group U, Group L).

Group U- Ultrasound group : Patients in this group underwent two-dimensional ultrasound guided right internal jugular vein cannulation.

Group L – Landmark group : Patients in this group underwent traditional blind anatomic landmark technique by central approach for right IJV cannulation.

Materials used :

In this study, a portable two-dimensional ultrasound machine with linear probe of 7.5 Mhz frequency manufactured by ESAOTE CARIS PLUS company was used. Sterile probe covering sheaths were used along with sterile conductivity gel (ultra/phonic gel- odourless, sterilized, hypoallergenic aqueous coupling agent for ultrasonic and electromedical procedures). The sterile kit containing the sterile sheath, a gel packet and two elastic bands is available and is marketed by Site~Rite IV Ultrasound System. The triple lumen central venous catheters manufactured by ARROW company for cannulation by Seldinger technique were used.

Selection of cases :

Inclusion criteria :

1. Age – 12 to 70 years
2. Elective IJV cannulation

Exclusion criteria :

1. Emergency cannulation
2. Pregnant women
3. Coagulopathy
4. Neck deformities

5. Local sepsis

6. History of previous cannulation

7. History of iv drug abuse

8. History of IJV thrombosis

Pre-anaesthetic evaluation :

Patients included in the study underwent thorough preoperative evaluation which included the following,

History :

History of underlying medical illness, previous surgery, anaesthesia and hospitalization.

Physical examination :

General condition of the patient

Vital signs

Examination of cardiovascular system, respiratory system, central nervous system, and vertebral column

Airway assessment.

Investigations :

Complete haemogram

Blood sugar, urea, Serum electrolytes, creatinine

Bleeding time, clotting time

Urine analysis

Electrocardiogram

Chest x-ray

Special investigations : Echocardiogram, cardiac catheterization, coronary angiogram

Patients who satisfied the inclusion criteria were explained about the nature of the study and the anaesthetic procedure. Written informed consent was obtained from all the patients included in the study.

Two persons were required during the study. One was the operator (myself) who did the cannulation and the probe adjustments. Second was the observer who was recording the parameters and helped in holding the probe during cannulation. All the parameters and events were observed and recorded in the proforma by the observer throughout the procedure.

Training :

The operator(myself) underwent basic ultrasound training for 2 weeks in the radiology department. A hands-on training was done on 10 patients who were selected based on the above mentioned criteria under the expert guidance of the radiologists and supervision of the senior anaesthesiologists.After the hands-on training , the observations and results were analysed in detail and based on the safety profile and success rate of the Ultrasound guided technique, the Institutional approval was obtained for conducting the present study.

Preparation :

Standard monitoring for cardiac patients was done. Intravenous access with two 16 G venflons were achieved. Premedication with inj.Midazolam 0.05mg/kg iv with inj.Morphine 0.1mg/kg was given. Patient positioned in 15* Trendelenburg position with a small bed roll between the shoulder blades, head turned slightly to the contralateral- left side, arms kept to the side of the body. Right IJV region exposed, cleaned and draped. Infiltration with 3ml of 1% lignocaine at the appropriate site of skin puncture given.

Technique :

Group-U

The real-time two dimensional ultrasound guided technique was performed with ESAOTE CARIS PLUS portable machine with a 7.5 Mhz linear probe. The machine was set in such a position that the operator had clear view of the monitor screen (set near the right arm of the patient while the operator stands at the head end of the patient). To maintain a sterile field the probe was covered in a sterile sheath and a sterile conductivity gel was used. In this study ,the time taken to setup the ultrasound machine was not included in the procedural duration. The operator stood at the head end of the patient and got oriented to the probe direction by determining the right and left side of the image. The probe was placed with the gel at the apex of the triangle formed by the two heads of sternocleidomastoid. The operator followed the real –time two dimensional ultrasound image showing the location, the depth, the size, and the anatomical relationship of IJV with the Carotid artery .

The IJV was distinguished from the Carotid artery by the following features :

IJV was

1. **Easily compressible with the probe,**
2. **Non-pulsatile**
3. **Showed marked enlargement during valsalva manoeuvre**

The operator centered the IJV on the screen and introduced a 18 G thin-wall needle with heparin saline loaded 5ml syringe from the superior aspect of the probe at the midpoint of the linear probe in skin contact. The trajectory of the needle was ascertained from the real-time ultrasound image and cannulation attempted. The anterior wall of the IJV was actually seen compressed before the needle entered the vessel. The needle position inside the lumen of the vessel was confirmed in the ultrasound image with simultaneous demonstration of free aspiration of dark venous blood in the heparin loaded syringe. The probe was held in this position by the observer , while the operator inserted the guide wire .The needle stabilization was done with constant monitoring of the image thus ensuring that the needle tip lies in the middle of the IJV lumen and thereby the guide wire insertion was done under vision. The regular steps of standard Seldinger technique was followed. The dilator was passed over the guide wire followed by threading of the Triple lumen central venous catheter . The guide wire was removed and the procedure ended with free aspiration of dark venous blood with the heparin saline loaded syringe.

Group-L

The classic Central approach for IJV cannulation was done. The operator stood at the head end of the patient. The anatomical landmarks were determined by palpating the two heads of the sternocleidomastoid muscle and locating the apex of the triangle formed by them. The

Carotid artery pulsation was felt 1 to 2cm medial to this point, beneath or just medial to the sternal head of the sternocleidomastoid muscle. A 22 G 1 ½ inch finder needle mounted on a 5ml heparin saline loaded syringe was first used to locate the IJV. The operator maintained slight or no pressure on the Carotid artery with the left hand and inserted the finder needle with the right hand at the apex of the triangle at a 30 to 45 degree angle with the frontal plane, directed at the ipsilateral nipple. After expulsion of any skin plug , the needle was advanced steadily with constant back pressure and venipuncture occurred within 3 to 5 cm. When venipuncture occurred with the finder needle demonstrated by the free aspiration of dark venous blood, the operator made a note of the direction and depth of the needle before withdrawing the finder needle. The 18 G thin wall needle mounted on a 5ml heparin saline loaded syringe was introduced in the identical plane and venipuncture was attempted in the same direction and depth. Once venipuncture occurred, free aspiration of dark venous blood was demonstrated. The syringe was removed during expiration or Valsalva maneuver and the hub occluded with a finger after ensuring that the backflow of blood is not pulsatile. The operator secured the needle in place with one hand while removing the syringe with the other. The was stabilized to prevent migration out of the IJV prior to guidewire insertion. The J tip of the guidewire was then inserted freely upto 20cm at which point the 18 G needle was withdrawn. With the guidewire in place, a scalpel was used to make a generous 90-degree stab incision at the skin entry site to facilitate passage of the vessel dilator. The dilator was inserted down the guidewire to the hub, ensuring that control and sterility of the guidewire was not compromised. The dilator was then withdrawn and gauze was used at the puncture site to control oozing and prevent air embolism down the needle tract. The triple-lumen catheter was then inserted over the guidewire, ensuring that the guidewire protruded from the distal lumen hub before the catheter tip penetrated the skin. The catheter was then advanced 15 to 17 cm into the vein, the guidewire was withdrawn, and the distal lumen capped. The catheter was sutured securely to limit tip migration .

If venipuncture did not occur at the initial thrust , back pressure was maintained and the needle slowly withdrawn . If the first attempt was unsuccessful, the operator should reassess patient position, landmarks and techniques. Subsequent attempts was directed slightly laterally or medially to the initial thrust after reassessment of the carotid artery position. If venipuncture did not occur with 18 G needle after insertion upto a depth 0.5cm more than that of a successful finder needle insertion in the same direction or inability to locate the IJV with 18 G needle for more than 30 sec , the attempt was considered as a missed attempt. The 18 G needle was withdrawn to the skin and a fresh attempt was done. If the guidewire did not pass easily beyond the tip of the 18 G needle, the guide wire was withdrawn, the syringe was attached, and free backflow of blood was reestablished. If this was not possible, the 18 G needle was withdrawn and a new attempt was done. If venipuncture was unsuccessful or cannulation was unsuccessful after 3 consecutive attempts with the 18 G needle or if the operator was unable to

Cannulation for more than 30min or the development of significant haematoma (> 2cm in any dimension) due to artery puncture , it was defined as failure. Failure was followed by an attempt to cannulate the right IJV (if there was no significant haematoma following arterial puncture) or left IJV (in case of significant haematoma) by the central landmark approach after marking the surface landmarks and the anatomical relations of IJV with the sorrounding structures with the help of a two dimensional ultrasound image.

Parameters observed :

1. The time taken with the probe/ the pilot needle to locate the IJV
2. The time taken with the 18 G needle to locate the IJV
3. The number of attempts required with the 18 G needle to successfully cannulate the IJV
4. The number of venipunctures required for the successful cannulation of the IJV
5. Failure to cannulate the IJV
6. Total access time
7. Acute complications observed
    i. Carotid artery puncture
    ii. Haematoma
    iii. Others (if any)

Definition of parameters :

1.The time taken with the probe/ the pilot needle to locate the IJV (in sec)

a) Probe time- The time was noted from the point of skin contact of the probe till centering real-time ultrasound image of the IJV on the screen. The time taken to setup the ultrasound machine was not taken into consideration.

b) Pilot needle time- The time was noted from the point of skin contact of the pilot needle till free aspiration of dark venous blood. The time taken to define the anatomical landmarks was not included.

2.The time taken with the 18 G needle to locate the IJV (in sec)

The time was noted from the point of skin contact of the 18 G needle till the free aspiration of dark venous blood confirmed the location of IJV during the final attempt that resulted in successful cannulation.

3. The number of attempts required with the 18 G needle to successfully cannulate the IJV

The total number of attempts required to successfully cannulate the IJV including the missed attempts were recorded.

Missed attempt : Defined as an attempt in which the venipuncture did not occur with 18 G needle after insertion upto a depth 0.5cm more than that of a successful finder needle insertion in the same direction or inability to locate the IJV with 18 G needle for more than 30 sec .

4. The number of venipunctures required for the successful cannulation of the IJV

The total number of venipunctures with the pilot needle and the 18 G needle required for successful cannulation were recorded.

5. Failure to cannulate the IJV

Failure was defined as procedure during which venipuncture was unsuccessful or cannulation was unsuccessful after 3 consecutive attempts with the 18 G needle or if the operator was unable to cannulate for more than 30min or the development of significant haematoma (> 2cm in any dimension) due to artery puncture. Failure was followed by an attempt to cannulate the right IJV (if there was no significant haematoma following arterial puncture) or left IJV (in case of significant haematoma) by the central landmark approach after marking the surface landmarks and the anatomical relations of IJV with the sorrounding structures with the help of a two dimensional ultrasound image.

6. Total access time (in sec)

The total time taken to successfully cannulate the IJV was recorded from the point of skin contact of the 18 G needle till the successful insertion of triple-lumen catheter was confirmed by the free aspiration of dark venous blood .

7. **Acute complications observed** :

a) **Artery puncture** : Carotid or Subclavian artery puncture during the procedure was documented. The artery puncture was followed by compression for 3 minutes to avoid haematoma formation.

b) **Haematoma** : The development of significant haematoma (> 2cm in any dimension)was documented.

c) **Other complications** : the other complications looked for were Haemothorax, haemomediastinum, arterial thromboembolism, pneumothorax, subcutaneous/ mediastinal emphysema , endotracheal tube cuff puncture.

OBSERVATION AND RESULTS

Fifty patients of either sex posted for major elective cardiac surgeries satisfying the selection criteria were randomly allocated into the two groups
(Group U, Group L - 25 patient each).

Group U- Ultrasound group : Patients in this group underwent two-dimensional ultrasound guided right internal jugular vein cannulation.

Group L – Landmark group : Patients in this group underwent traditional blind anatomic landmark technique by central approach for right internal jugular vein cannulation.

Table 1a : Demographic profile

Parameter	Group	No. of patients	Mean	SD	Students 't'-test
Age (in years)	**Ultrasound**	25	31.96	14.70	't'= 0.21, p=0.84 Not significant
	Landmark	25	31.12	13.78	
Height (in cms)	**Ultrasound**	25	152.76	8.05	't'=0.52, p=0.60 Not significant
	Landmark	25	153.92	7.48	
Weight (in kgs)	**Ultrasound**	25	52.40	12.55	't'=0.55, p=0.59 Not significant
	Landmark	25	54.24	11.23	

Table 1b : Sex profile

Group	Sex		Total
	Male	Female	
Ultrasound	15	10	25
Landmark	11	14	25
Total	26	24	50

$\chi 2=1.28$ P=0.26 - not significant

The two groups were similar with respect to age, height, weight, sex .

Table 2 : The time taken with the probe/ the pilot needle to locate the IJV

Group	No. of patients	Mean (in sec)	SD	Students 't'-test
Ultrasound	25	8.88	1.333	t=2.73 P=0.01 Significant
Landmark	25	10.18	1.887	

The Ultrasound group required less time (8.88 +/- 1.333 sec) to locate the IJV when compared to the Landmark group (10.18 +/- 1.887 sec) , which was **statistically significant .**

Table 3 : The time taken with the 18 G needle to locate the IJV

Group	**No. of patients**	**Mean (in sec)**	**SD**	**Students 't'-test**
Ultrasound	25	9.20	1.443	t=5.26 P=0.001 Significant
Landmark	25	11.84	2.055	

The Ultrasound group required considerably less time (9.20 +/- 1.443 sec) to locate the IJV with the 18 G needle when compared to the Landmark group (11.84 +/- 2.055 sec) and this was found to be **statistically significant**.

Table 4 : The number of attempts required with the 18 G needle to successfully cannulate the IJV

Group	No. of patients successfully cannulated at			
	1st attempt	**2nd attempt**	**3rd attempt**	**4th attempt**
Ultrasound	25	0	0	0
Landmark	14	8	2	1

$\chi 2$=14.1 P=0.003 significant

In the Ultrasound group , cannulation was successful at first attempt in all the 25 patients. In the Landmark group, only 14 patients were cannulated at first attempt, 8 patients required 2 attempts , 2 patients required 3 attempts, 1patient required 4 attempts (which was a case of failure to cannulate).

The difference was found to be **statistically significant.**

Success rate at first attempt :

Group U 25/25=(100%)

Group L 14/25 =(56%)

$\chi 2$ = 14.01 P=0.001 significant

The Landmark group had only 56% success rate at first attempt, whereas, the Ultrasound group had a 100% success rate at first attempt and this difference was found to be **statistically significant.**

Missed attempts :

Group	No. fo patients with			
	No missed attempts	**1 missed attempt**	**2 missed attempts**	**3 missed attempts**
Ultrasound	25	0	0	0
Land mark	13	9	2	1

$\chi 2=15.79$ $P=0.001$ significant

The Landmark group had **significantly** more number of missed attempts when compared to the Ultrasound group.

Table 5 : The number of venipunctures required for the successful cannulation of the IJV

Group	**No. of venipunctures**		
	1	**2**	**3**
Ultrasound	25	0	0
Land mark	0	21	4

$\chi 2=50$ P=0.001   significant

Landmark group required an average of 2.16 venipunctures for successful cannulation, whereas the Ultrasound group required only one venipuncture for successful cannulation.

This difference in the number of venipunctures required for successful cannulation was found to be **statistically significant.**

Table 6 : Failure to cannulate the IJV

Group L 4/25 =(16%)

Group U 0/25=(0%)

$\chi_{2 \text{Fisher exact test}}$ P=0.05 significant

The Landmark group had a **significant** failure rate of 16% when compared to the Ultrasound group 0% .

Table 7 : Total access time (in sec)

Group	No. of patients	Mean (in sec)	SD	Students 't'-test
Ultrasound	25	252.80	6.602	T=3.35 P=0.002 Significant
Land mark	25	313.36	90.026	

The Ultrasound group required less time for central venous access (252.80 +/- 6.602 sec) when compared to the Landmark group (313.36 +/- 90.026 sec). There was considerable delay in the Landmark group . The difference in the total access time of the two groups was found to be **statistically significant.**

Table 8 : Acute complications observed

a) **Artery puncture rate**

Group L 6/25 =(24%)

Group U 0/25=(0%)

$\chi 2_{=4.73}$ P=0.01 significant

All the six inadvertent artery punctures (with the 18 G needle) involved the Carotid artery in the Landmark group and there were no artery punctures during the Ultrasound guided cannulation. This complication was found to be **statistically significant.**

b) **Haematoma rate**

Group L 3/25 =(12%)

Group U 0/25=(0%)

$\chi 2_{\text{Fisher exact test}}$ P=0.11 not significant

50 % of the arterial punctures (3 out of the 6) in the Landmark group

were followed by haematoma formation. But the incidence of haematoma was **not statistically significant**.

STATISTICAL ANALYSIS

Mean and standard deviation were estimated for the various parameters in each group. The mean values were compared by student's independent 't' test.

Proportion and variables from each study group were compared by Pearson's Chi-square test and Fischer's exact test.

In this study, **'p' value < 0.05** was considered as level of significance.

DISCUSSION

The observations and results show a clear benefit from two dimensional real-time ultrasound guidance for internal jugular venous access compared with the Landmark method. This is manifest in a lower technical failure rate (overall and on first attempt), a reduction in complications, and faster access. One explanation for these benefits is that ultrasonography clarifies the relative position of the needle, the vein, and it's sorrounding structures. The image offered by real-time two dimensional ultrasonography allows the user to predict variant anatomy and to assess the patency of a target vein. These findings are similar to the results of previously published studies and meta-analysis of randomized controlled studies comparing these two techniques.

Demographic profile

The major prospective controlled trials comparing the Ultrasound guided technique with the Landmark technique of IJV cannulation were conducted in Cardio-thoracic patients : **Troianos et al (48) ,1991,USA, Vucevic et al (53) , 1994, UK, Gratz et al (47) , 1994, USA, Sulek et al (55) ,2000,USA** .In the study conducted by **National Institute of Clinical Excellence (56) , UK, 2002** , a systematic review and mata- analysis of 4 trials done in adult cardiac settings were included.

The present study included the patients posted for major elective cardiac surgeries like Coronary artery bypass grafting, Valve replacement surgeries (Mitral/Aortic/both), repair of Atrial septal defect. This clinical setting was chosen based on the results during the period of hands-on training under the expert guidance of the Radiologists. Further more, this controlled environment of Cardiothoracic operation theatre provided sufficient facilities and safety features for the conduct of the study. In the present study, both the two groups were similar with respect to age, height, weight and sex .

The time taken with the probe/ the pilot needle to locate the IJV (in sec)

The institutional protocol insists on the use of a pilot needle for the Landmark technique and hence this parameter was observed and analysed. None of the previous studies included this parameter and hence, this time parameter was not included in the other time recordings (Time taken to locate the IJV with 18 G needle, Total access time)

Probe time- The time was noted from the point of skin contact of the probe till centering real-time ultrasound image of the IJV on the screen. The time taken to setup the ultrasound machine was not taken into consideration.

Pilot needle time- The time was noted from the point of skin contact of the pilot needle till free aspiration of dark venous blood. The time taken to define the anatomical landmarks was not included.

In the present study, the Ultrasound group required less time (8.88 +/- 1.333 sec) to locate the IJV with the probe when compared to the Landmark group (10.18 +/- 1.887 sec) with the pilot needle, which was statistically significant. This was because the moment the probe was placed on the skin and adjusted, the ultrasonic image immediately showed the relative position of the vein and it's sorrounding structures making the process easier than with the pilot needle.

The time taken with the 18 G needle to locate the IJV (in sec)

The time was noted from the point of skin contact of the 18 G needle till the free aspiration of dark venous blood confirmed the location of IJV during the final attempt that resulted in successful cannulation.

Denys et al [40] – In their study found that the average skin to vein time was 9.8 sec (2 to 68 sec) by the Ultrasound approach and 44.5 sec (2 to 1,000 sec) by the Landmark approach ($p < 0.001$).

In the present study, the results were in concurrence with the above study, the Ultrasound group required considerably less time (9.20 +/- 1.443 sec) to locate the IJV with the 18 G needle when compared to the Landmark group (11.84 +/- 2.055 sec) and this was found to be statistically significant ($p= 0.001$).

<u>The number of attempts required with the 18 G needle to successfully cannulate the IJV</u>

The total number of attempts required to successfully cannulate the IJV including the missed attempts were recorded.

Troianos et al [48] – In this trial, the mean number of attempts required in the Ultrasound group was found to be less 1.4 (+/- 0.7) when compared to the Landmark group 2.8 (+/- 3.0).

Gratz et al [47] – In this trial, the mean number of attempts required in the Ultrasound group was found to be less 1.35 (1-4) when compared to the Landmark group 2.8 (1-10).

Verghese et al [54] – In this trial, the mean number of attempts required in the Ultrasound group was found to be less 1.3 (+/- 0.6) when compared to the Landmark group 3.3 (+/- 2.8).

In the present study, it was found that in the Landmark group, only 14 patients were cannulated at first attempt, 8 patients required 2 attempts, 2 patients required 3 attempts, 1patient required 4 attempts (which was a case of failure to cannulate). In contrast, in the Ultrasound group, the cannulation was successful at first attempt in all the 25 patients. The mean number of attempts required in the Landmark group was 1.6 (+/-0.8) while the Ultrasound group required only 1 attempt in all cases. The number of attempts included the missed attempts, attempts in which inadvertent artery puncture occurred and the attempts in which IJV was hit but cannulation could not be done because of needle tip displacement. The difference was found to be statistically significant (p= 0.003).

The more number of attempts with the 18 G needle significantly increased the risk of complications in the Landmark group.

Success rate at first attempt :

Troianos et al [48] – In this trial, the Ultrasound group had a higher success rate at first attempt (73) than the Landmark group (54%).

Gratz et al [47] – In this trial, the Ultrasound group had a higher success rate at first attempt (85%) than the Landmark group (55%).

In the present study, the Landmark group had only 56% success rate at first attempt whereas, the Ultrasound group had a 100% success rate at first attempt, and this difference was statistically significant (p=0.001). The higher success rate in the present study when compared to the previous studies can be attributed to the smaller study population included.

Missed attempts :

Missed attempt was defined as an attempt in which the venipuncture did not occur with 18 G needle after insertion upto a depth 0.5cm more than that of a successful finder needle insertion in the same direction or inability to locate the IJV with 18 G needle for more than 30 sec .

In the present study, the Landmark group had significantly (p=0.001) more number of missed attempts (mean 0.64) when compared to the Ultrasound group(0).

The number of venipunctures required for the successful cannulation of the IJV

The total number of venipunctures with the pilot needle and the 18 G needle required for successful cannulation were recorded.

All the previous studies were done without the use pilot needle . Since the institutional protocol insists that a pilot needle be used in the Landmark group to decrease the complications, venipuncture with the pilot needle was also included in the present study.

In the present study, Ultrasound group required only one venipuncture for successful cannulation. All the patients in the Landmark group had minimum of two venipunctures of the IJV (Pilot needle + 18 G needle). In addition, because of the difficulty in cannulation 4 patients in the Landmark group required the third venipuncture with the 18 G needle for successful cannulation. This difference in the number of venipunctures was found to be statistically significant (p=0.001).

Failure to cannulate the IJV

The failure was defined in various terms (including the duration of procedure, the number of attempts, etc.,) in the different studies.

Hind et al [57] – The rate of failed catheter placement was less in the Ultrasound group (1.7 %) when compared to that of the Landmark group (22%).

NICE Study 2002 UK [56] – In this study, it was found that Ultrasound guidance was associated with reduced risks of failed catheter placements (56% reduction in the risk, 95% CI, 67% to 94%, $p < 0.001$)

In the present study, Failure was defined as procedure during which venipuncture was unsuccessful or cannulation was unsuccessful after 3 consecutive attempts with the 18 G needle or if the operator was unable to cannulate for more than 30min or the development of significant haematoma (> 2cm in any dimension) due to arterial puncture. Failure was followed by an attempt to cannulate the right IJV (if there was no significant haematoma following arterial puncture) or left IJV (in case of significant haematoma) by the central landmark approach after marking the surface landmarks and the anatomical relations of IJV with the sorrounding structures with the help of a two dimensional ultrasound image.

In the present study, the Landmark group had a significant failure rate of 16% when compared to the Ultrasound group 0% ($\chi_{2\text{Fisher exact test}}$ P=0.05 significant). Out of the four failure cases, three had significant haematoma and underwent left IJV cannulation, one case which required more than three attempts had no haematoma and so, underwent right IJV cannulation. But it must be noted that all the four cases of failure in the Landmark group were cannulated at first attempt after surface marking of the IJV using the two dimensional ultrasound image.

Total access time (in sec)

The total time taken to successfully cannulate the IJV was recorded from the point of skin contact of the 18 G needle till the successful insertion of triple-lumen catheter was confirmed by the free aspiration of dark venous blood .

Troianos et al [48] – In this study, there was significant reduction in the time taken for cannulation in the Ultrasound group 61 sec (15-180 sec) when compared to the Landmark group 117 sec (8-400 sec).

Gratz et al [47] – In this study, there was significant reduction in the time taken for cannulation in the Ultrasound group 109 sec (6-470 sec) when compared to the Landmark group 226 sec (5-1200 sec).

In the present study also, the Ultrasound group required less time for central venous access (252.80 +/- 6.602 sec) when compared to the Landmark group (313.36 +/- 90.026 sec). There was considerable delay in the Landmark group due to various factors like inadvertent artery puncture, compression of artery puncture, haematoma obscuring the anatomy, missed attempts, difficulty in cannulation, failure of cannulation. The difference in the total access time of the two groups was found to be statistically significant.

But the difference in the values when compared to the previous studies was probably due to the difference in definitions for total access time in the protocol and the differences due to the operator's experience in the various studies.

Acute complications observed :

Complications were probably due to the existence of normal anatomic variations, positioning errors and increased number of attempts with the 18 G needle.

Troianos et al [48] – In this study, there was reduced incidence of carotid artery punctures in the Ultrasound group (1.4%) when compared to the Landmark group (8.43 %).

Hind et al [57] - In this study, the relative risk of complications using the Ultrasound was 43% less than the risk of using the Landmark technique.

Verghese et al [54] – In this study, the carotid artery puncture rate was 0% in the Ultrasound group when compared to 25 % in the Landmark group.

In the present study , the major complication was the carotid artery punctures. The Arterial puncture occurred in six out of 25 cases studied (24%) in the Landmark group whereas there were none in the Ultrasound group(0%) All the inadvertent arterial punctures (with the 18 G needle) involved the Carotid artery in the Landmark group . This complication was found to be statistically significant group ($\chi2_{=4.73}$ P=0.01, significant).

The second major complication was Haematoma following the artery puncture. The Haematoma occurred in three out of 25 cases (12%) in the Landmark group whereas there were none in the Ultrasound group (0%). Inspite of the compression given, 50 % of the artererial punctures (3 out of the 6) in the Landmark group resulted in haematoma formation obscuring the anatomy and led to the cannulation of the Left IJV (defined as Failure).But the incidence of haematoma was not found to be statistically significant ($\chi_{2\text{Fisher exact test}}$ P=0.11, not significant)

SUMMARY

In this study comparing the two dimensional real-time ultrasound guided technique with the traditional blind anatomic landmark technique for the placement of central venous catheter in the internal jugular vein the following parameters have been observed and statistically analysed : the time taken to locate the IJV, the number of venipunctures, the number of attempts required to successfully cannulate the IJV, the total access time, the success rate, the failure rate, the complication rate .

1. The mean time taken with the pilot needle / probe to locate the IJV in the

    Landmark group - 10.18 + - 1.887 sec

    Ultrasound group - 8.88+- 1.333 sec

Significant reduction in the time taken to locate the IJV while using the Ultrasound guided technique.

2. The mean time taken with the 18 G needle to locate the IJV in the

    Landmark group - 11.84 +- 2.055 sec

    Ultrasound group - 9.20 +- 1.443 sec

Significant reduction in the time taken to locate the IJV with 18 G needle while using the Ultrasound guided technique.

3. Successful cannulation at first attempt in the

    Landmark group - 14/25 – 56%

    Ultrasound group - 25/25 – 100%

Significant reduction in the number of attempts required for successful cannulation while using the Ultrasound guided technique.

4. The mean number of venipunctures required for successful cannulation in the

   Landmark group - 2.16

   Ultrasound group - 1.0

Significant reduction in the number of venipunctures required for successful cannulation while using the Ultrasound guided technique.

5. Failure rate

   Landmark group - 16%

   Ultrasound group - 0%

Significant reduction in the failure while using the Ultrasound guided technique.

6. The mean total access time in the

   Landmark group - 313.36 +- 90.026 sec

   Ultrasound group - 252.80 +- 6.602 sec

Significant reduction in the total access time while using the Ultrasound guided technique, thereby facilitating speedy central venous cannulation.

7. Complication rate

a) Carotid artery puncture rate

Landmark group - 24%

Ultrasound group - 0%

b) Haematoma rate

Landmark group - 12%

Ultrasound group - 0%

Significant reduction in the complication rate while using the Ultrasound guided technique.

CONCLUSION

Ultrasound guided cannulation of the internal jugular vein significantly improves the success rate, decreases the access time, and reduces the complication rate. The Ultrasound guided technique is a better technique than the traditional blind anatomic Landmark technique for IJV cannulation. The use of ultrasound should be seen as an extension of the traditional skills rather than a completely new technique eventhough it requires hands-on training. In addition, the Ultrasound guided technique is a potentially useful back-up technique in complicated cases where Landmark technique is unsuccessful.

In conclusion,

"Two dimensional ultrasound guided internal jugular vein cannulation is quicker, safer, and more successful than the traditional blind anatomical landmark technique".

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COMPARISON OF THE TWO DIMENSIONAL ULTRASOUND GUIDED TECHNIQUE VERSUS THE TRADITIONAL BLIND ANATOMIC LANDMARK TECHNIQUE FOR THE PLACEMENT OF CENTRAL VENOUS CATHETER IN THE INTERNAL JUGULAR VEIN

PROFORMA

Date :

Name of the patient : Age : Sex :

IP No. :

Diagnosis :

Surgical procedure planned :

Pre-anaesthetic check up :

H/O Systemic illness :

H/O Previous IJV cannulation :

Any other relevant history :

General examination :

Local examination (neck) :

Height : Weight :

Vital Signs : BP- PR- RR- SpO2-

CVS :
RS:
P/A :
CNS :

Investigations :

ASA Status :

Airway assessment :

Anaesthesia :

Central venous catheter insertion :

Technique : USG-guided (Group U)
Landmark technique (Group L)

Parameters observed :

1.Time taken with the probe / pilot needle to locate the IJV :

2.Time taken with the 18 G needle to locate the IJV :

3. Number of attempts with the 18 G needle to successfully cannulate the IJV :

4. Number of missed attempts :

5. Number of venipunctures for successful cannulation :

6. Total access time :

7.Failure to cannulate :

8. Acute complications :

8. Artery puncture :

9. Haematoma :

10. Other complications :